

Oct. 14, 1969

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3,472,191

HYDROPNEUMATIC SALVAGE SYSTEM

Filed June 20, 1967

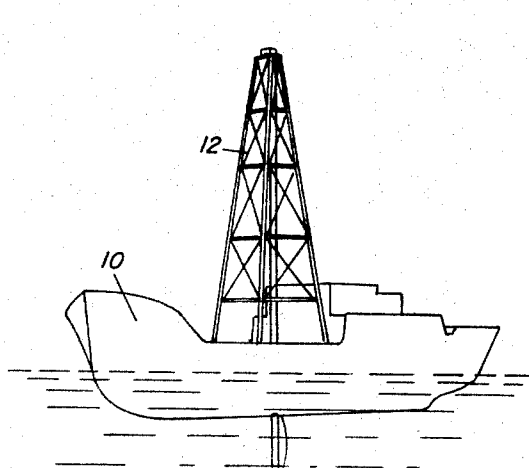


FIG. 1

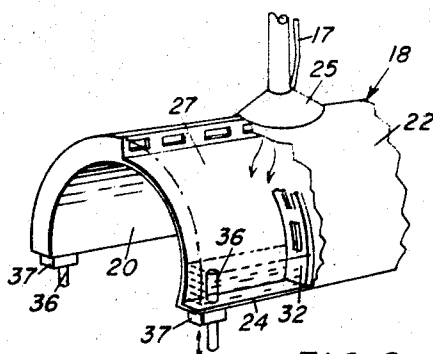


FIG. 2

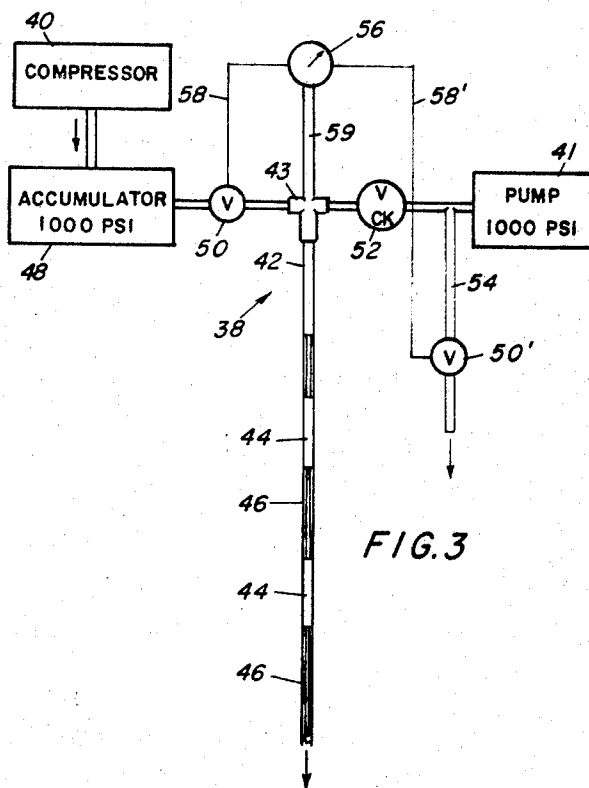


FIG. 3

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HYDROPNEUMATIC SALVAGE SYSTEM

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Filed June 20, 1967, Ser. No. 647,482

Int. Cl. B63c 7/20, 11/50

U.S. Cl. 114-52

9 Claims

ABSTRACT OF THE DISCLOSURE

A system and apparatus for retrieving objects from great water depths which includes a hollow vessel having grappling hooks mounted thereto and a pressure system for rendering the vessel positively buoyant by utilizing long columnar heads of water in combination with an air compressor having a relatively low pressure capability.

This invention relates to an apparatus for raising sunken objects from great depths and more particularly relates to an apparatus for raising such objects by hydropneumatic means.

The present invention will carry out salvage operations at depths heretofor believed impractical for meaningful results. As will be explained, apparatus which embodies this invention can be used for lifting several thousand tons from depths of more than 20,000 feet. Heretofore, the use of air and gas at great depths has proved unfeasible for the reason that air compressors, which can satisfy the high air pressure requirements when working at such depths are not commercially available and gas generators for these pressures are dangerous because of the explosive nature of the gases which must be used. In order to overcome these problems and limitations, it is a primary object of the invention to provide a salvaging apparatus for engaging and raising a sunken object at depths of several miles by means of a lifting vessel which is buoyed by pressures obtained through a two-phase fluid flow of air and water.

Another object of this invention is to provide a ship salvaging apparatus which can recover objects from great depths by the use of air compressors and water pumps commercially available with output pressures on the order of 1,000 p.s.i.

Another important object of the invention is to provide a hydropneumatic pumping means to pressurize a submerged lifting chamber to relatively high pressures by using compressors having relatively low output pressures.

Another important object of the invention is to provide an apparatus for pressurizing air by building up a columnar pressure head of alternate volumes of air and water which acts downwardly to increasingly compress each succeeding lower air volume.

A yet further object of the instant invention is to provide an apparatus which employs both a pipe string and an attached pressurized container for lifting sunken objects.

These and other objects of the invention will become more apparent to those skilled in the art by reference to the following detailed description when viewed in light of the accompanying drawings, wherein:

FIGURE 1 show a diagrammatic perspective view of the invention with a pipe string and hollow lifting vessel in place ready for raising a sunken object;

FIGURE 2 is a detailed perspective partly in section of a hollow lifting chamber; and

FIGURE 3 is a diagrammatic-schematic view of the hydropneumatic pumping system.

Referring now to the drawings, wherein like numerals indicate like parts, a ship 10 is shown positioned over

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an object to be retrieved. A derrick or tower 12 is secured topside thereof and is of the type common to the oil drilling industry. Derricks of this type sequentially secure and combine a series of pipe sections 14 into a pipe string 16. The pipe sections 14 are secured together, usually by mating threads, as is well known to the art. The joints between these pipe sections must be sufficiently tight to prevent leakage during submersion. Extending the length of the pipe string and secured to the outer wall of each pipe section, is an electric control cable 17.

Rigidly secured to the bottom end of the pipe string at 25 is a lifting vessel 18. The electrical cable 17 extends from an electric power source and its controls on the deck to the vessel for accomplishing certain movements of grappling devices hereinafter described. The vessel 18 is semi-cylindrical in configuration and includes parallel inner and outer walls 20 and 22, end walls 24, and side walls 26. A chamber 27 is defined therebetween. The dimensions of the vessel 18 may of course vary according to the object to be raised but the chamber should be large enough so that the inner wall 20 will fit in surrounding relation over the particular object to be raised. Although not depicted in the drawings, the positioning of the vessel 18 over the object can be accomplished by a remote steering means such as hydraulic steering jets.

A series of grab arms 26 are pivotally secured along both sides of the lower end of the outer wall 22. A series of double-acting, self-contained, hydraulic or electric motors 30 are pivotally secured at their upper respective ends to the outer wall 22 and at their lower ends to one of the grab arms. The motors 30 are actuated by an electrical signal through cable 17. As can readily be seen, an extension of the motors 30 will cause the grab arms 26 to close around the bottom of the object M to be raised.

The interior of the vessel is provided with a series of perforated reinforcing ribs 32 which communicate the interior of the vessel with the pipe string 16. A plurality of vent pipes 36 are located through each end of the end walls 24 and extend into the chamber. The vent pipes are vertically adjustable by small electric motors 37 which receive their power via cable 17. The adjustable vent pipes provides a means whereby a selected level of water ballast may be maintained within the vessel chamber.

A hydropneumatic pumping system is diagrammatically displayed in FIGURE 3 and is generally represented by the numeral 38. The system 38 is provided to inject alternate slugs of water and air into the feed pipe. The system includes an air compressor 40 and a water pump 41 which are each connected to the feed pipe at the T-junction 43. The air compressor 40 delivers pressurized air to an accumulator 48 which maintains a supply of air at a predetermined pressure. The outlet from the accumulator goes to junction 43. An automatic air-operated valve 50 is disposed between the accumulator and the feed pipe. The outlet from the water pump 41 goes to the junction 43 of the feed pipe via a one-way check valve 52. A water bypass line 54 is provided intermediate the check valve 52 and the water pump and includes an air-operated valve 50'. Both air-operated valves 50, 50' are controlled by a pressure regulator 56 via the lines 58 and 58'.

The regulator 56 controls the air-to-water ratio delivered to the feed pipe 42 by monitoring the back pressure in the feed pipe via the line 59. When the back pressure reaches a certain preselected value, the regulator closes the valves 50, 50' thus stopping the flow of air from entering the feed pipe and simultaneously causing an injection of water through valve 52. As the weight of the water on top of the previous slug of air in the feed pipe increases the back pressure will diminish and, when this back pressure reaches a certain preselected lower

value, the regulator automatically opens valves 50, 50'. Water prevented from entering the feed pipe is discharged overboard through line 54. When valve 50 is opened, another air injection on top of the previously delivered water slug enters the feed pipe 42. The range set on the regulator 56 between starting and stopping water injection controls the length of the water slugs needed to overbalance the hydrostatic head and carry the air slugs to ever-increasing depths.

Because of the sequential operation of the valves, the pumping system will inject a successive series of air slugs 44 and water slugs 46 into the pipe. The operation of this two-phase fluid flow will result in continuing compression of the air slugs as it is forced downwardly through the pipe string. In other words, the pressure head of the column of air and water above each lower air slug will increase as the pump system 38 continues to operate. Upon reaching the chamber 18, the water slugs will fall by gravity to the bottom of chamber 22 and the excess above the vent pipes 36 will be discharged to the sea. The air slugs will remain in the chamber to further pressurize it.

The vent pipes 36 have a further purpose. Since the pipes protrude above the inner surface of the end walls a water ballast sufficient to maintain the vessel negatively buoyant can be retained in the vessel. Thus, there is no concern for the chamber rising to the surface uncontrolled on its own.

In operation, the chamber 18 is water filled until it is negatively buoyant so as to facilitate its lowering. The vents 36 are raised to a selected level to insure the negative buoyancy. After the chamber has been lowered to a position over the sunken object, the motors 30 are actuated to move the grab arms 26 to their engaging position. If during the lowering operation pipe 14 cannot support the dead weight of the chamber, air slugs can be inserted to reduce the negative buoyancy. Depending on the weight of the object to be retrieved, the vertical height of the vent pipes can be adjusted in order to provide the system with a correct lifting buoyancy. The pipe string 14 is then raised through the tower 12. As the retrieved object is raised an increase in the pressure differential occurs. The air within the container will exhaust through pipes 36 to thus maintain a fixed buoyancy relationship.

Even though the above-described system is capable of lifting great weights, the vessel 38 can be manufactured using unusually lightweight construction techniques. The reason for this is that since the air pressure in the vessel is always slightly higher than the ambient water pressure, the structural integrity of the vessel is increased.

What has been set forth above is intended primarily as exemplary to enable those skilled in the art in the practice of the invention and at should therefore be understood that, within the scope of the appended claims, the invention may be practiced in other ways than as specifically described.

What is new and therefore desired to be protected by Letters Patent of the United States is:

1. The method of raising a submerged object comprising the steps of lowering a hollowed vessel to a position adjacent said object, attaching said vessel to said object, communicating the interior of said vessel via a feed pipe to a source of water and to a source of compressed air at a location above said vessel, injecting alternate slugs of water and compressed air into said pipe means, exhausting said slugs of water from said vessel and capturing said slugs of air therein until the air pressure reaches a level that sufficient water is exhausted from said vessel to render the combined weight of said vessel and said object buoyant enough that they can be raised by said feed pipe.

2. The method of claim 1 wherein the amount of air and water is regulated to depend on the pressure in said pipe at said location.

3. Apparatus for raising a submerged object from relatively great depths below the surface of a body of water comprising a hollow vessel, a relatively rigid feed pipe attached to and communicating the interior of said vessel to a hoisting means above the water surface, attaching means attached to said vessel to secure said vessel to said object, adjustable vent means to retain sufficient ballast in said vessel to insure its negative buoyancy as said vessel is lowered to a position adjacent said objects, and means to exhaust sufficient of said ballast from said vessel to render said vessel positively buoyant to thereby reduce the combined weight of said object and said vessel when secured together by said attaching means.

4. Apparatus for raising a submerged object from relatively great depths below the surface of a body of water comprising a hollow vessel, a feed pipe attached to and communicating the interior of said vessel to a location above the water surface, attaching means to secure said vessel to said object, first means to retain sufficient ballast in said vessel to insure its negative buoyancy as said vessel is lowered to a position adjacent said object, and second means to exhaust sufficient of said ballast from said vessel to render said vessel positively buoyant to thereby reduce the combined weight of said object and said vessel when secured together by said attaching means, said second means comprising an air compressor and a source of water, a first conduit communicating said air compressor to said feed pipe and a second conduit communicating said water source to said feed pipe, and regulator means for alternating injecting amounts of compressed air and water into said feed pipe.

5. The invention described in claim 4 wherein said regulator means includes a sensing conduit in communication with said feed pipe, a first valving means between said compressor and said feed pipe and second valving means causing water to enter said feed pipe when said first valving means obstructs the flow of air between said compressor and said feed pipe.

6. The invention described in claim 5 wherein said regulator means includes further means to vary the amount of water delivered to said feed pipe in relation to the amount of air delivered thereto.

7. A salvage system for raising a submerged object comprising a ship disposed over said object, a feed pipe depending downwardly from said ship to the vicinity of said object, derrick means on said ship for raising and lowering said feed pipe, a hollow vessel secured to the lower end of said feed pipe, a vent stem communicating the interior of said vessel to the surrounding water, clamping means affixed to said chamber for engaging said sunken object; pumping means on said ship for pumping successive slugs or air and water into said vessel through said pipe string, means to trap said air in said vessel, said pumping means including a regulator means for adjusting the amount of water relative to the amount of air injected into said pipe such that the columnar weight of the water and air in said feed pipe in addition to the air pressure output of said pumping means produces a combined pressure greater than the pressure of the water at the level of said object.

8. Apparatus for raising a submerged object from relatively great depths below the surface of a body of water comprising a hollow vessel, said hollow vessel having a concave inner surface, a feed pipe attached to and communicating the interior of said vessel to a location above the water surface, attaching means to secure said vessel to said object, said attaching means comprising grappling members attached to said vessel having a first position over said inner surface and a second retracted position, first means to retain sufficient ballast in said vessel to insure its negative buoyancy as said vessel is lowered to a position adjacent said object, and second means to exhaust sufficient of said ballast from said vessel to render said vessel positively buoyant to thereby reduce the com-

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bined weight of said object and said vessel when secured together by said attaching means.

9. Apparatus for raising a submerged object from relatively great depths below the surface of a body of water comprising a hollow vessel having a bottom surface, a feed pipe attached to and communicating the interior of said vessel to a location above the water surface, attaching means to secure said vessel to said object, first means to retain sufficient ballast in said vessel to insure its negative buoyancy as said vessel is lowered to a position adjacent said object, said first means including vent pipes extending into said vessel through said bottom surface and a remotely controlled motor means for selecting the required ballast by varying the distance between said bottom surface and the upper ends of said vent pipes, and second

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means to exhaust sufficient of said ballast from said vessel to render said vessel positively buoyant to thereby reduce the combined weight of said object and said vessel when secured together by said attaching means.

References Cited

UNITED STATES PATENTS

1,495,529	5/1924	Reno	114—52
3,339,513	9/1967	Cloutier	114—50

FOREIGN PATENTS

622,900	5/1949	Great Britain.
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